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1. Your reference P/61767.GBA/VISD

2. Patent application number *(The Patent Office will fill in this part)* 05 MAR 1999 9905051.0

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*
Patents ADP number *(if you know it)*

EEV Limited
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United Kingdom

39673850002

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention
Chemical Sensor Systems

5. Name of your agent *(if you have one)* G. Cockayne

1009133003

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)* GEC Patent Department, Waterhouse Lane, Chelmsford, Essex CM1 2QX

Patents ADP number *(if you know it)*
1009133003

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Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
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YES

Patents Form 1/77

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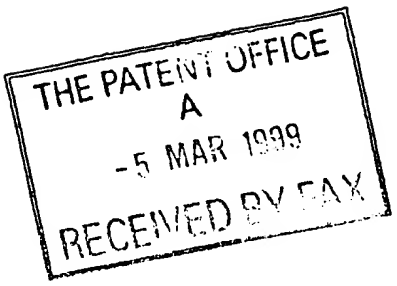
Continuation sheets of this form 0

Description 9

Claim(s) 3

Abstract 0

Drawings(s) 1



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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)* (-)

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Request for substantive examination *(Patents Form 10/77)* (-)

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11. I/We request the grant of a patent on the basis of this application.

Signature Date 5 March 1999

12. Name and daytime telephone number of person to contact in the United Kingdom G. Cockayne - Telephone No. 01245 275459

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Chemical Sensor Systems

This invention relates to chemical sensor systems, and more particularly for at- or on-line monitoring of a product or process.

Chemical sensor array systems for sensing in the liquid, gas or vapour phase, including as a sub-class those arrays sometimes referred to as electronic noses as they operate using odour analysis, have been successfully employed in laboratory instruments for the measurement of headspace volatiles. Typical applications include quality control of raw materials and final product, new product development and correlation with sensory panel data. Those instruments developed to date have primarily aimed at laboratory use.

In applications where substances are being handled or modified during manufacture or processing, there are typically several stages during the process where there is a requirement for assessment of quality, authenticity and/or compositional property of a substance. Chemical sensor array systems (SAT) may be used in assessing these characteristics.

The present invention seeks to provide a chemical sensor system which is particularly suitable for at-line or on-line monitoring.

According to the invention, there is provided a chemical sensor system for at or on-line monitoring of a product or process comprising: sampling means arranged to acquire samples of a substance to be sensed from a plurality of different locations in the product or process line; sensor means including an array of sensors arranged to sense the samples; and

processing means for deriving information from the output of the sensor means concerning the substance or substances to be sensed.

As used in this specification, "at-line" means that a monitoring instrument is located next to the detection point of interest, from which a sample may be introduced either manually or by automated means. Analysis of the product or process is achieved from a discrete sample or batched samples. The term "on-line" is defined to mean that there is a physical connection between the monitoring system and the detection point, which allows the product or process to be monitored by discrete samples, batched samples or continuously with automated sampling. "In-line" systems are a subset of on-line systems.

By using the invention, it is possible to analyse samples of substances from different locations in a product or process line and to assess them together within the process system as a whole or to assess samples individually. This would, for instance, provide a means of monitoring at several stage during a production process. The substance sampled at a plurality of different locations may be nominally the same substance or it could be another substance introduced, modified or generated during a production process. More than one substance may be sensed at a single location to give a more complete characterisation of the manufacturing or process line.

The advantage of using monitoring technology in an at-line or on-line configuration is that it enables 'point of use' or in-situ measurement of a sample which in turn allows real-time monitoring of a product or process. A process to be monitored may involve one or more physical or chemical procedures used in the treatment, conversion or manufacture of an

intermediate or final product. In a manufacturing environment at- or in-line monitoring allows rapid corrective action to be taken if there has been a deviation from normal or acceptable performance or quality in product or process. The delay in taking a sample for remote off-linc analysis in a laboratory-based instrument is often unacceptable. At and on-line monitoring is therefore preferable in many areas of industry and also in environments where the system is monitoring for hazardous conditions e.g. fire or generation of toxic vapours.

The sampling means may be incorporated as part of the sensor means, with sensors of thc sensor means being placed at a detection point of interest. The sampling means might alternatively be discrete from the sensor means. Examples of the sample means are arrangements using at least one of the following techniques to acquire a sample: portable; liquid headspace; liquid sparge; sample vaporisation; a probe; solid head space; direct insertion of an array of liquid phase chemical sensors into the sample or sample stream; gas line and ambient monitoring. For a particular system, it is necessary to select a sample handling technique appropriate to the substance to sensed.

A sample handling apparatus extracting a sample from a liquid head space is suitable for monitoring ambient volatiles above a liquid sample, liquid sparge comprises flushing a liquid sample with inert gas to release volatiles. A probe may comprise, for example, a flexible tube and pump to acquire a sample. In a solid head space, ambient volatiles are monitored above a solid sample. A gas line might be used in which a sample is drawn off from a gas stream, this being particularly suitable for processes involving fermentation. A sample handling module may use an ambient technique such as passive monitoring of the

local environment, for example, for fire detection. Other techniques may be appropriate for other applications. Where a sample is to be monitored in the liquid phase a sensor array may be inserted into the sample or sample stream.

The sample handling means may be such as to acquire a sample without operator intervention to give an automated procedure, and samples may be taken at discrete time intervals which are fixed or variable, or continuously. Also, switching between discrete, batched and continuous sampling may take place depending on the particular time in a production process, location of which the sample is taken or for some other reason.

In one system, the sampling apparatus includes means to introduce a calibration or reference sample. Alternatively, this may be provided at the sensor mode means. This allows calibration or checking of the sensor array performance.

The distributed chemical sensor system may provide information concerning the operation of a production line or a process which can then be used in a control feedback system, in which data generated by the system is fed back to determine the settings of control hardware, for example, in a System Control and Data Acquisition (SCADA) system. Feedback may also be provided to the monitoring system itself, for example, to adjust sensor settings or sampling frequency.

In one embodiment of the invention, the sensor means comprises a plurality of sensor arrays located at respective different locations. This minimizes the path to be taken between the sampling means and sensor means, where these are separately housed, as each sensor

array module may be located at the detection point at which the sample is acquired.

In a chemical sensor, a change in a physical property, such as a change in electrical conductivity, is produced in response to a gas or vapour being sensed. Many different sensor technologies are available for use in the sensor means. Advantageously, the sensor means includes a sensor array using at least one of the following types of sensor technology: mass sensitive sensor; electronic conductance or capacitance sensors; field effect sensors; calorimetric sensors; electrochemical sensors (for example, amperometric, potentiometric or conductimetric sensors); optochemical or photometric sensors; and biosensors. In fact any sensor which produces a useful output corresponding to a change in characteristic when a chemical is sensed may be suitable. Mass sensitive sensors may be for example those using bulk acoustic wave or surface acoustic wave techniques. Electronic conductance and capacitance sensors may be for example chemo-resistors based on conducting polymer or metal oxide semiconductor materials. Calorimetric sensors may for example be pellistors. Electrochemical sensors are for example potentiometric cells. Infra red and fibre optic based techniques may be used in optochemical or photometric sensors. Biosensor and electrochemical sensors may be particularly suitable for liquid phase sensing.

A system in accordance with the invention may include a sensor array having sensors of one technology type only. In that case, the sensor environment can be specifically tailored for use with sensors of that type. In alternative arrangements, the sensor array includes sensors of a combination of different technology types. This gives increased sensitivity and/or discrimination in some cases, the particular combination being tailored to the substance to be sensed.

The processing means may be arranged to simultaneously accept information relating to samples acquired from respective different locations or obtaining information sequentially. The information obtained from the samples taken at different points may individually be used to give an assessment of the state of the product or process on-line or they may be used in combination. Thus, the processing means may classify substances at individual locations or classify the status of the line as a whole.

Preferably, the processing means uses pattern recognition to characterise the substance. The pattern recognition technique used in the processing module may use at least one of the following: a statistical method (for example, principal component analysis (PCA), or multiple discriminant analysis (MDA)); fuzzy logic; an artificial neural network; and a proprietary classifier algorithm. The technique or techniques adopted depend on the substance to be sensed and the use made by the system of information acquired via the monitoring procedure.

One way in which the invention may be performed is now described by way of example with reference to the accompany drawing in which the sole Figure schematically illustrates a chemical sensor system in accordance with the present invention.

With reference to the Figure, a chemical sensor array system is used to monitor a product manufactured by a process including several processing steps. In this case it is wished to monitor the composition of a substance at various points in the processing method to assess the effectiveness of the process line. The monitoring system includes a sampler 1 at

a first point A at which a sample of the substance is extracted using an appropriate sampling technique. In this case, a sample is taken at fixed timing intervals. The container in which the sample is housed is connected via a pipe to a sensor array module 2 in such a way that volatiles existing in the headspace above the solid sample are transferred over sensors of the array. The output of the sensors is determined by their response to the volatiles to which they are exposed. In this case, the sensor array module 2 combines a plurality of different sensor technologies providing a set of signal outputs characteristic of the substance of the sample. A central processor 3 accesses the outputs of the sensor array module 2 via a fixed link 4 to provide a series of data points characteristic of the sample being sent. Pre-processing occurs in the central processor 3 to place the acquired data in a form suitable for pattern recognition techniques to be applied thereto.

A second sampler 5 is arranged to take samples downstream of location A at a second location B at which stage it is expected that the substance being processed has been modified. A sample is taken by the sample handling means 5 in a way appropriate to the form of the substance and the most appropriate types of sensor technology to detect changes in its physical or chemical characteristics. The sample is presented to a second sensor array module 6 which is located locally to the sample handling means 5. The second sensor array module 6 produces a set of responses characteristic of the composition of the substance being sampled. These are also accessed by the central processor 3. Additional samples may be taken at other points of detection in the process line. These points of detection may be downstream of the first one or could be at locations A and B but arranged to take samples of different substances.

The central processor 3 is arranged to apply a suitable pattern recognition technique to the data required from the second sensor array module 6. The processor 3 then assesses the data derived from each sensor array module in turn to characterise the substance sampled at the point of detection associated with that sensor array module. In addition, the central processor 3 provides an overview of the production line as a whole to characterise the entire process system.

The information which results from the processing stage is then applied by a link 7 to a user interface 8, which in this case takes the form of a visual display from which an operator may view the performance of the system. In addition, the user interface 8 permits the operator to input control data, for example, to vary the frequency at which samples are taken, control characteristics of sensors in the sensor array modules 2 or 6 or to implement different functions of the central processor 3. Other changes to the monitoring system may be arranged to be implemented or automatically via the central processor 3. For example, if the central processor 3 detects rapid changes in characteristics of a set of samples, it may send control signals to the sample means to increase the rate at which samples are taken.

The central processor 3 is also linked via line 9 to a manufacture control system 10 which utilises the information acquired from the monitoring system to adjust the parameters of the process line in dependant on any detected variations from the sample composition from the desired characteristics.

The central processor 3 may be set up so that it is able to acquire data communicated from either a single sensor array module or from several and place them into a form which is

suitable for further processing. A pattern recognition technique may be applied to each sensor array module in turn or to a plurality of sensor array modules simultaneously.

CLAIMS

1. A chemical sensor system for at- or on-line monitoring of a product or process comprising: sampling means arranged to acquire samples of at least one substance to be sensed from a plurality of different locations in the product or process line; sensor means including an array of sensors arranged to sense the samples; and processing means for deriving information from the output of the sensor means concerning the substance or substances to be sensed.

2. A system as claimed in claim 1 wherein locations at which the samples are taken are remote from one another.

3. A system as claimed in claim 1 or 2 wherein locations at which the samples are taken are local to one another.

4. A system as claimed in claim 1, 2 or 3 wherein the sensor means comprises a plurality of sensor arrays located at respective different locations.

5. A system as claimed in claim 4 wherein the sensor arrays are housed in separate modules.

6. A systems as claimed in any preceding claim wherein sampling means and sensor means are housed in a common module.

7. A system as claimed in any preceding claim wherein the processing means is arranged to acquire simultaneously information relating to samples acquired from respective different locations.

8. A system as claimed in any of claims 1 to 6 wherein the processing means is arranged to acquire sequentially information relating to samples acquired from respective different locations.

9. A system as claimed in any preceding claim wherein processing means is arranged to apply pattern recognition to data relating to the samples.

10. A systems as claimed in any preceding claim and including a user interface.

11. A systems as claimed in any preceding claim and including means for deriving signals to control the product or process line in dependance on the samples sensed.

12. A system as claimed in any preceding claim and including means for controlling the sampling means and/or sensor means in depcndance on information derived from the samples sensed.

13. A system as claimed in any preceding claim wherein the processing means provides control signals to the sensor means.

14. A system as claimed in any preceding claim wherein the sensor means comprises at least

one sensor array module which includes sample handling capability.

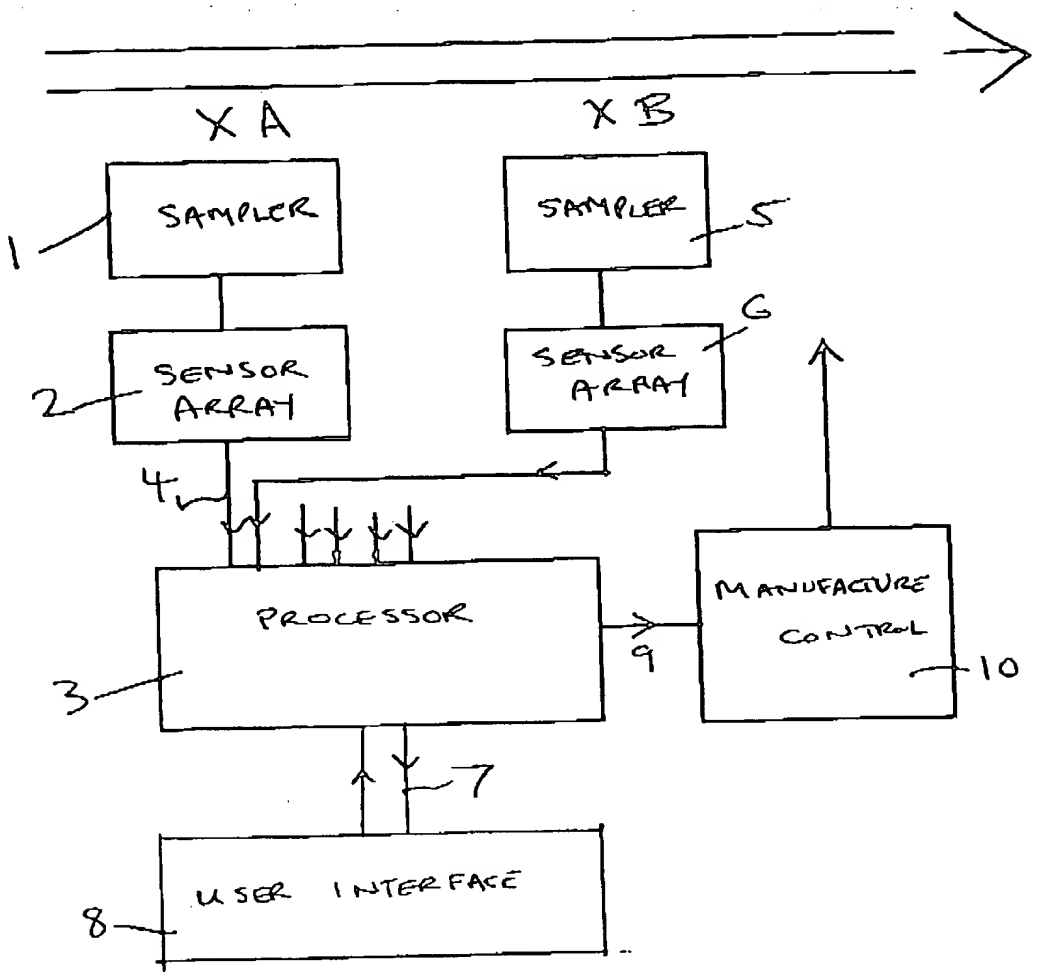
15. A system as claimed in any preceding claim wherein the sensor means includes at least one of the following types of sensor technology: mass sensitive sensors; electronic conductance or capacitance sensors; field effect sensors; calorimetric sensors; electrochemical sensors; optochemical or photometric sensors; and biosensors.

16. A system as claimed in any preceding claim wherein the sensor means including sensors of only one sensor technology type.

17. A system as claimed in any of claims 1 to 15 wherein the sensor means includes sensors of a combination of different technology types.

18. A system as claimed in any preceding claim wherein the sampling means uses at least one of the following techniques to acquire a sample: portable; liquid headspace; liquid sparge; sample vaporisation; a probe; solid head space; direct insertion of an array of liquid phase chemical sensors into the sample or sample stream; gas line and ambient monitoring.

19. A chemical sensor system for at- or on-line monitoring of a product or process substantially as illustrated in and described with reference to the accompanying drawing.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